University of California, Berkeley
Physics 226: Particle Physics Phenomenology
General Information
Fall 2009

Instructor: Prof. Marjorie Shapiro

Lecture Hours: TuTh 12:30-2PM, 385 LeConte

Discussion Section: Tu 4-5PM

Office Hours: Tu 2:30-4PM, 445 LeConte

Email: mdshapiro@lbl.gov

Web Page: http://physics.lbl.gov/shapiro/Physics226/Physics226.html

Course Description:

This class provides an introduction to particle physics phenomena. Emphasis is placed on experimental tests of particle physics theories. Topics include: overview of detectors and accelerators, quark model spectroscopy, weak decays, e^+e^- annihilation, parton model, hadron collider physics, neutrino oscillations and physics beyond the standard model.

References:

No textbook is required for the class. Plots shown in class, along with useful references will be posed on the lab web site. The following texts are useful references:

- Halzen and Martin: *Quarks and Leptons: An Introductory Course in Modern Particle Physics*, Wiley & Sons (1984)
- Donoghue, Golowich & Holstein, *Dynamics of the Standard Model*, Cambridge University Press (1992)
- Goldhaber and Cahn *Experimental Foundations of Particle Physics*, Cambridge University Press (new addition to be out this year)
- Perkins *Introduction to High Energy Physics* Cambridge University Press (2000)

Homework and Grading:

Homework assignments will be roughly weekly and will posted on the class web site. You are encouraged to work with your fellow students but you must present your own solutions. For some of the problems, you will need access to the ROOT interactive analysis package. This package is free and downloadable. You should be able to use root on your laptop or on PANIC. The class will have no midterm or final exam. The grade will be based on the homework.

Physics 226 Syllabus

- Lecture 1: Introduction to the Standard Model
  - The matter fields: quarks and leptons
  - The gauge fields: photons, $W^{\pm}$, Z^0, gluons
  - Open questions: Higgs sector, CP non-invariance, grand unification
- Lectures 2-3: Detectors and Accelerators
  - Interaction of particles with matter
  - Charged particle detectors
  - Calorimetry
  - Accelerators
- Lecture 4: Elements of Statistics
  - Probability
  - Statistics
  - Monte Carlo Methods
- Lectures 5-7: Global Symmetries and Conservation Laws
  - Lepton and Baryon Number
  - C, P and CP
  - The proton and neutron: Introduction of isospin
  - Kaons: Introduction of Strangeness
  - $\mathrm{SU}(3)_{\mathrm{flavor}}$ and the quark model
  - The need for $\mathrm{SU}(3)_{\mathrm{color}}$
- Lectures 8-9 Brief Overview of Scattering Cross Sections and Decay Rates
  - Feynman Rules: A Cookbook approach to Feynman Diagrams
  - Particle Decays and Angular Structure
- Lectures 10-11 The Structure of the Nucleon
  - Discovery of scaling
  - Measuring the spin and charge of the quarks
  - The antiquark content of the nucleon
  - Definition of structure functions
  - Scaling Violations and the need for QCD

- Lectures 12-15 Strong Interactions
  - The gluon and the QCD LaGrangian
  - $e^+e^- \rightarrow$ Hadrons
  - Quarkonium
  - $p\overline{p}$ and pp Collisions
- Lectures 16-23 Weak Interactions
  - Parity Non-Conservation and (V-A) Weak Interactions
  - Weak Decays (μ, π, Λ)
  - Kaon Decays and CP Violation
  - The CKM Matrix
  - Decays of Heavy Quarks
  - Neutral Currents
  - Modern Electroweak Theory
  - Selected Results from LEP, the Tevatron, Babar and Belle
  - Neutrino Mass and Neutrino Oscillations
- Lecture 24 Electoweak Symmetry Breaking
  - The Higgs Mechanism
  - Alternatives to the SM
- Lectures 25-28 Beyond the Standard Model
  - Supersymmetry
  - Extra Dimensions
  - Grand Unification
  - Connections With Cosmology